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THE JOURNAL OF INDUSTRIAL HYGIENE

AND ABSTRACT OF THE LITERATURE

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How Far Should Industry Go in Caring for Cases of Illness Not Due to Employment?

New Apparatus for Artificial Respiration: The Barospirator of Professor T. Thunberg

Quantitative Measurements of the Inhalation, Retention, and Exhalation of Dusts and Fumes by Man: I. Concentrations of 50 to 450 Mg. per Cubic Meter

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THE JOURNAL OF INDUSTRIAL HYGIENE

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HOW FAR SHOULD INDUSTRY GO IN CARING FOR CASES OF ILLNESS NOT DUE TO EMPLOYMENT?*

ROBERT P. KNAPP, M.D.

Medical Director, Cheney Brothers, South Manchester, Conn.

MOST industrial medical departments, nowadays, automatically fall into two classes: the defensive departments and the offensive departments. The word "offensive" is here being used in relation to the elimination of disease. There is a third, rather hybrid group, which is a combination of both—an attempt which is made in a defensive department to carry on a mild and rather half-hearted offensive against ordinary illness, offered as a placebo.

The defensive department was born purely to comply, in as economical a manner as possible, with the letter of the Workmen's Compensation Act, and its concern is almost solely with compensable industrial injuries and diseases. Here little thought is given to prevention or to treatment of ordinary illnesses; the thought uppermost is always to cope successfully with the compensation condition, and therein, of course, such departments are wholly ethical and logically laudable.

Of offensive medical departments it is only fair to say in explanation that most of them, in addition to being on the offensive, are also always on the defensive with regard to compensable conditions, an attitude which is naturally to be expected.

The extent to which an offensive against disease should be carried on by an industrial medical department has always been debatable, and the extent to which such an offensive is carried on in various industries is dependent entirely on the policy and the scope of this work as the individual industry sees it.

One of the chief reasons why medical work, other than the treatment of compensation cases, should be attempted in industry is because of the unrivaled opportunity which the full time industrial physician has for

*Received for publication Oct. 29, 1927.

getting the case early, and for studying it exhaustively, oftentimes preventing an acute breakdown in the person's health by proper attention to the facts which the previous diagnostic work has disclosed. The physician outside of the mill, more often than not, sees a patient only when he is acutely ill, having had little or no opportunity to study his physical condition prior to the illness; for that reason this physician is not in a position to treat the patient with quite the same vision as he would if he had studied the case longer. Moreover, for the same reason he very often prescribes a change of work, seemingly not caring to what work the man is changed so long as the change is made to work that is easier. He does not realize how impractical this attitude very often is; he does not know that there are only so many jobs in the mill and that these are usually all taken. Consequently, it is very difficult indeed always to comply with the request when an outside doctor sends a patient who is an employee back to a plant with instructions to change his work. The industrial physician is in a position, very frequently having studied the case over a period of weeks, perhaps months, to apprise the man that he will probably need a change of work and that this fact will be kept in mind, and that when a proper job for him is open he will be assigned to it. In short, the industrial physician being on the job at the plant every day, studying the cases and their needs, knowing what can be done for the men at the plant, is in a much better position to adjust the job and fit a man to suitable work than is the outside doctor who knows little of the actual conditions pertaining to this man's work.

In one other regard the industrial physician has a distinct advantage over the outside physician: He is not working upon a fee basis and he can, therefore, encourage the man to have an exhaustive study made of his case at less cost than can the physician outside the plant. In other words, the cost to the patient does not continue to mount as the patient continues to call at the medical department, whereas it does if he continues to have an outside physician. If the patient can afford to pay for treatment, I should say that it is perfectly all right for him to be treated by his family physician, but if it is going to be a financial hardship for him to pay the price of an exhaustive physical study, I should then say that the offer, gratis, of the facilities of the plant medical department is certainly a distinct boon to him.

This offensive should be carried out, to my mind, quite thoroughly; in fact, some industries have seen this in the light of a complete job, and the workers have been attended by the company's medical staff not only at the plant, but in their homes, for every conceivable ailment with the possible exception of contagion. This, of course, means that an industry with many operatives must employ several physicians and many nurses, and, consequently, the general practitioners in the community suffer. It is unfair competition, as the industry has the first knowledge of the worker's need of a doctor and is, therefore, first on the job.

This situation also makes the worker

feel almost entirely dependent on the industry for medical attention, which to many impartial observers brings about paradoxically an unhealthy outlook of the worker toward the industry. He is made to lean too heavily on the industry during his hours away from work and is, therefore, robbed of initiative, which is detrimental to his best interests. This brings us to our question, "How far should industry go in caring for cases of illness not due to or arising out of employment?"

That a great deal of good can come out of the care of the ailing worker is undeniable, and such a course is merely dependent on the will of the management to sponsor it. That such an offer of medical care will be alike accepted and refused is, of course, to be expected when any consideration at all is given to the various individual mental make-ups that occur in all industries. It is not always the most enlightened person who accepts industrial medical attention. He need only be sufficiently enlightened to realize that it is for his own good. In fact, he may not even realize this, but accepts the service because of economic pressure. It may be said, however, that it is generally the most unenlightened, or, better, the unenlightened generally who refuses to accept industrial medical attention, always provided, of course, that what is offered by an industry is as good as can be offered. Therefore, while it is easily seen why a worker will accept good medical attention offered by industry, it is not quite so easily understood why he refuses—in fact, in many instances no adequate reason can be ascribed.

First, the worker may have the something-for-nothing complex or, rather, antipathy, and the fact that the treatment is gratis is repellent to him. Often in these cases the placing of a small charge for the service is sufficient to make him accept it. Again the very fact that the *industry* is offering the service may mean to the worker one of two things, perhaps both: The service either is not much good, or there is some ulterior motive in the offer—the industry has some occult reason for suggesting it. Then there are the closely allied objections: one, that no industrial doctor can know as much about the ailments of a worker as does the worker's own family physician, and, second, that the worker does not care to have the industrial doctor know as much about his ailments as does his family physician, either from purely personal reasons or for economic reasons, fearing that the information might be used against him and he might lose his job. There may be other reasons but these will suffice to hang our case upon.

All the above-mentioned reasons for refusal to accept medical attention offered by the industry should be unfounded fears, provided the industry is entirely altruistic in its offer. It may be, of course, that this has not always been the case and, if true, such a policy is most reprehensible, as it deliberately betrays a trust. Provided the offer is genuine, however, can industry expect eventually to overcome all these unfounded fears? No, because it is impossible, no matter how honest the service, to convince everyone that the offer is genuine, human nature being what it always has been. But in the long run—and long is here

used advisedly, for it is a slow process for many persons before they become convinced of the worth of such attention—in the long run you may hope to convince some of the most ardent doubters.

How should the management go about installing such a service and how far should the care be extended? Answering the last part of the question first, it seems to be the consensus of opinion of physicians in many varied types of industry that industry is justified in treating patients so long as they are able to report to the plant dispensary for treatment, but that when they are unable to come to the dispensary they should be referred to their family physicians.

The situation in one community would permit an industry to do more for its workers than would be permitted in another community; thus the local situation has a large influence in this work. Industry profits from adequate medical service, as it saves time both for the employee and for the employer. It makes workers more contented by often diagnosing physical faults for those unable to pay the fees of private physicians, thereby enabling them to have work done which would otherwise be neglected. Such work also enables the employer to check up on the hazards of employment. This, however, can be done only when adequate records of absence due to illness are kept.

With regard to the first half of the question, that of the policy of medical departments, it may be said that, in the first place, whatever service is offered should be of the best and all facts pertaining to a person's illness should be kept strictly confidential between the doctor and the patient. This must be insisted upon if the complete confidence of the worker is to be won. Next, the medical service offered should be as complete as it can be made; that is, the more diagnostic aids the plant medical department supplies, the more satisfactory should be the results and the quicker these should be obtained. This means that if a case is to be solved, the nature of which is not readily discernible, considerable time may have to be spent on it; this again is an important factor in successfully diagnosing the illness of the worker. If he is not given sufficient time or if it appears that such is the case, he becomes dissatisfied and may not return, and that is a normal reaction and one which we ourselves would probably exhibit. Another point that is paramount to success is the keeping of adequate records. Not only must a complete history of the case and the physical examination be recorded, but also all laboratory and X-ray results must be kept with the case card, and further, whenever the case is sent to a consultant, a copy of the industrial physician's letter of reference and the consultant's reply should be with the case record; it is important that a written reply should always be obtained from the consultant for any possible future reference, and particularly for the satisfaction of the patient.

A well-equipped medical department should include besides the surgical dressing rooms separated consultation rooms for the taking of histories, etc., a laboratory for the usual chemical and microscopic tests, and an X-ray laboratory which is quite essential not only to the diagnosis of industrial

accidents, but also for nonindustrial cases where the X-ray may clear up the diagnosis. In this connection, while speaking of laboratories, a point which may be overlooked but which is a very essential one is the fact that the patient should be apprised of the result of every laboratory test or X-ray made. This may sound to some readers superfluous, and to others entirely unnecessary. Experience, however, has taught me that both these viewpoints are wrong, and I was some time in learning it. To be sure, perhaps the majority of persons on whom tests are made are interested in the results not at all or only to a slight extent. Speaking conservatively, a certain minority, while they may not voice this wish to the doctor, nurse, or technician, will to their closer friends wonder out loud many times why they were never told the result of this laboratory test or that X-ray examination. This first came to my notice at our foremen's meetings where the grievances of workers which had been expressed to their foremen were aired for solution, and I think later it was brought out at a Works Council meeting. At all events it is something real which exists in the minds of the workers, and I have found that the simplest and best solution for it is to send a small slip, signed by the doctor who ordered the test, to each patient after each result of an X-ray or a laboratory test is known to the doctor, stating briefly as follows: "The examination of your (what ever it was), made on (date), was (normal) (abnormal). If abnormal, please see the doctor for further information." This covers the situation and informs the patient; in fact, in the majority of cases the findings in the tests that we make are normal, and where they are abnormal the patient has only to come to the medical department to receive in detail an explanation of what this abnormality may mean. He is satisfied because he does not feel that his test was made in vain—a reaction which I think would be a normal one for any of us, were we of the laity. In other words, the worker gladly submits to the tests, and I say this advisedly, for we have very few objections considering the great number of tests we do. For example, we do routine urinalysis and Wassermann tests on all our applicants for employment. Since the worker gladly submits to these tests, should he not know the result? The answer is, he should.

Besides the subdivisions mentioned above, a well-balanced physiotherapy department in charge of a competent technician is, nowadays, not only something which shortens the treatment in many cases but something which the worker expects.

A dental department where either a hygienist alone is employed or both a dentist and a hygienist are supplied is a big aid not only in keeping the workers' mouths in healthy condition, but also often in assisting to make a diagnosis.

To the foregoing may be added the following: a staff of competent physicians and graduate nurses for correlating the various sections of the medical division already mentioned, and one or two nurses to do the visiting—and this latter work should be solely nursing, not investigating causes of absence, otherwise logical suspicion on the part of the worker will be run foul

of and comparatively little nursing will be done (supply, if you will, an extra person unconnected with the medical division for such purposes, but never have it an integral part of the duties of the medical division); further, a physician either on part time or on full time, probably the former, to do eye refractions on stated days—this is a big time saver for both the employer and the employee, and if the product requires visual acuity this will tend to improve its quality; and, lastly, a visiting consultant to come once a fortnight to examine chest cases, possibly tuberculous. A medical department will thus be rounded out which is equipped to do most anything in the line of diagnosis.

The question what charge, if any, should be made for the service to employees for diagnosis and treatment of other than industrial accidents and illnesses is handled differently by various plants. In some cases no charge at all is made for any of the work. To this policy the objection may be offered that the service will not be appreciated, and undoubtedly this is true many times.

Some plants make a charge per treatment which varies in amount from 25 cents to $1 for everything except the actual consultation, advice, and treatment from the physician, which may or may not be gratis, but in my estimation should be. Again a blanket charge of so much a year or a month may be made which in the aggregate may cover any and all costs. This is certainly easier to handle; but regardless of whether a charge is made or not, there seems no reasonable objection to the plan of treating at the plant industrial workers' nonindustrial illnesses and accidents as well as their compensable conditions, and certainly much good can be expected from the presence of such a service.

NEW APPARATUS FOR ARTIFICIAL RESPIRATION: THE BAROSPIRATOR OF PROFESSOR T. THUNBERG*

CECIL K. DRINKER, M.D.

THE subject of artificial respiration has commanded persistent attention for almost two hundred years. A variety of ideas have dominated the minds of investigators during this time. There was, first of all, a period in which reliance was placed upon different measures thought to be stimulating, as for example rectal insufflation of tobacco smoke, stimulation of the nasal mucous membrane with brandy or foul-smelling material, or the actual introduction of snuff or pepper. All these bizarre methods received strong support and, for all, apparently successful resuscitations could no doubt be claimed. Certainly this is true for the rectal use of tobacco smoke, a procedure which was disposed of only after careful experimentation.

Undoubtedly mouth to mouth insufflation is the oldest of the direct efforts at resuscitation, and the practice of this method led naturally to the use of bellows. John Hunter was responsible for the first substantial suggestions in this mechanical direction, and by 1800 apparatus blowing air into the lungs for inspiration and sucking it out for expiration was in active use. The devices employed have been figured by Keith (1) and compare quite favorably with their modern grandchild, the pulmotor, which operates on this same plan.

* Received for publication Oct. 11, 1927.

By the middle of the nineteenth century simple manual methods began to appear, first of all designed to produce inspiration by stretching the pectoral muscles and widening the chest, and expiration by a combination of stretch release and thoracic pressure. The efforts of Silvester (2) and his many followers will be recognized in this line of work which produced excellent results.

Schäfer (3), in 1908, gave final form to the method which bears his name and which provides expiration by strong pressure on the lower thorax and abdomen and inspiration through the simple rebound following release of pressure. Both the Silvester and the Schäfer methods can be applied by means of fairly simple machines, but since the usefulness of manual methods consists in avoiding anything which seems to elaborate them, these decidedly artificial aids have never attained popularity.

The pulmotor operates by blowing air plus oxygen to the patient through a face mask and withdrawing it by light suction. The apparatus has had great prominence but has not been recommended for use by any one of the several impartial groups of physicians and physiologists appointed to examine it. The reasons for rejection of this highly ingenious device consist in the uncertainty of blowing sufficient air into the lungs through a face mask unless the machine is set to operate at

a dangerously high pressure, and in the fact that suction always seals the face mask and makes this phase of the operation of the machine unduly efficient. The apparatus devised by Meltzer (4) in 1917 blows air into the lungs through a pharyngeal tube. In highly trained hands it could be made to avoid most of the difficulty attendant upon the use of the pulmotor, but the method has never attained even a thoroughgoing field trial.

All these methods attempt to move a reasonable volume of air or air plus oxygen into and out of the lungs. They contrast with the newest procedure, inhalation of 95 per cent. oxygen and 5 per cent. carbon dioxide, devised by Henderson and Haggard (5), which is a return to the old idea of stimulation but upon a perfectly conceived physiologic basis. While this method is most effective in breathing subjects, it has proved thoroughly applicable combined with artificial respiration (Drinker (6)). A more recent attempt at respiratory stimulation, the use of lobelin, has been found of uncertain efficacy and probable danger (Norris and Weiss (7)).

Thunberg (8) and his associates (9) (10) have published several papers, not readily available for those interested in industrial hygiene, which describe an apparatus for artificial respiration operating on a wholly new principle.

Breathing is accomplished by bringing a certain volume of air into the lungs and then expelling it, and all methods of artificial respiration, whether manual or instrumental, operate in the same volumetric manner. Invariably the thorax must expand and contract in order to accomplish the movement of a sufficient volume of air to meet the necessities of life. Thunberg, taking advantage of simple physical laws, proposes to substitute what may be called pressure breathing for the ordinary variety or volume breathing. "Let us think," he says, "of a large air-tight, air-filled room *A*, containing a small open vessel, a glass flask *B*, for example, which through its opening is in free communication with room *A*. If, now, the pressure in *A* is rhythmically raised and lowered by means of an air pump, for each rise in pressure in *A* more air will move into *B*, and when the pressure in *A* falls air must flow out of *B*. . . . . And it is observed that this ventilation of flask *B* is accomplished in spite of the fact that the volume of the flask is constant during the entire time."

From this simple illustration it is apparent that one can provide a good supply of air by pressure ventilation instead of volume ventilation, and Thunberg makes this more emphatic by showing that a small glass bell with a hole in the top may be substituted for the vessel *B* in our hypothetical illustration, and the Barospirator for room *A*. By rhythmic pressure changes in *A*, one readily ventilates *B* so as to keep the candle alight. Figure 1 illustrates the simplest type of Barospirator. *A* is a boiler, large enough to admit the body of a man, as shown in Figure 2. It is closed by the door *E*. The tube *K* leads to the cylinder *B*, in reality a large air compressor operated by an electric motor *C*. *D* is a driving wheel so arranged as to enable one to alter the stroke of the piston. The cylinder *B* is large, and the pressure changes in *A* resulting from the movements of

the piston within it are shown by the manometer *F*. *G* is a valve which is kept somewhat open so that the air in *A* is always undergoing renewal. Owing to the oversize of cylinder *B*, this valve may be kept widely open without interfering with a satisfactory change of pressure in *A*. *H* is a muffler above valve *G* and *I* a port for inspection of the subject when closed in *A* by the door *E*.

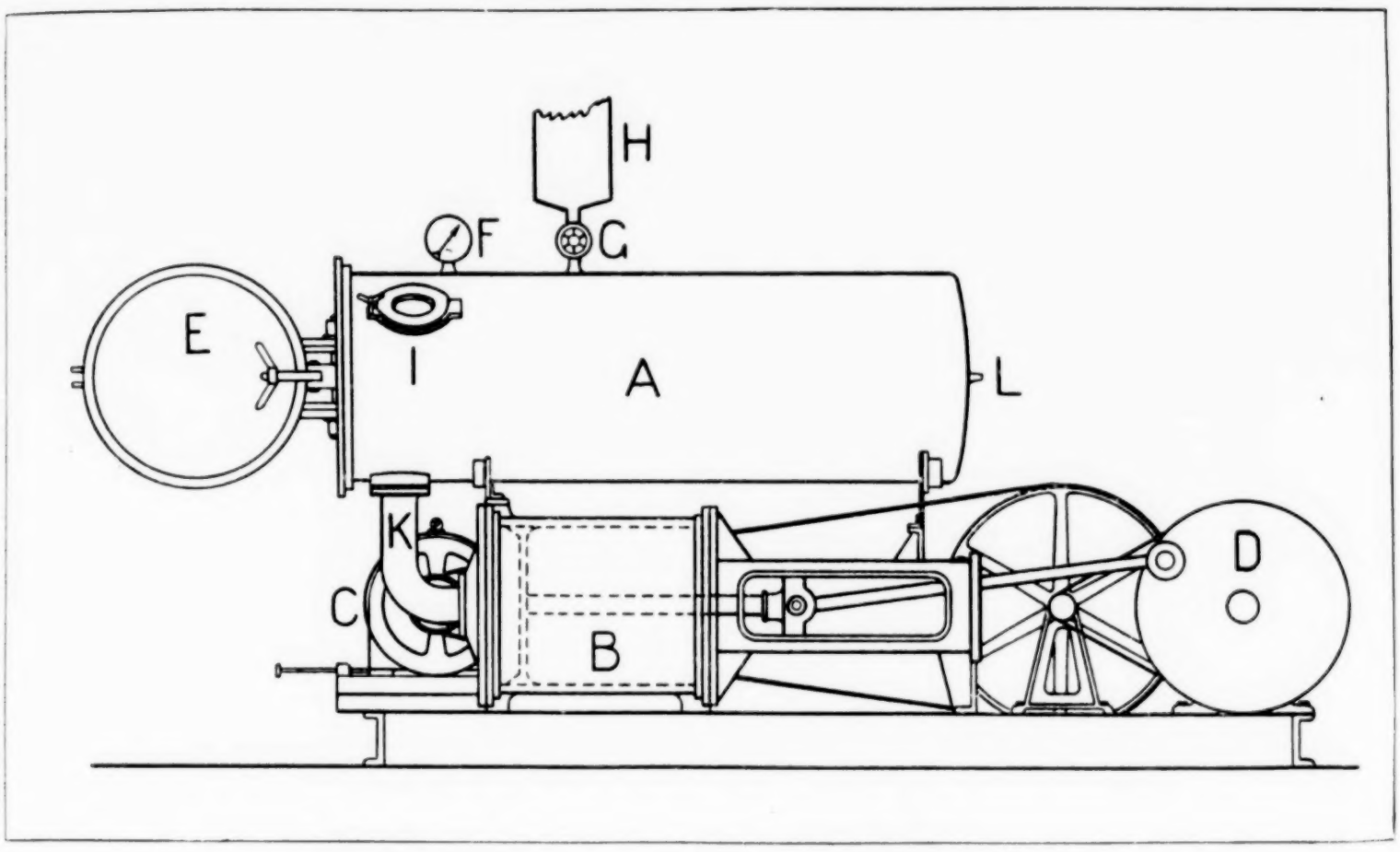

FIG. 1.—Diagram of simplest type of Barospirator.

Figure 2 shows a subject on the sliding stretcher upon which he is moved into the machine, and Figure 3 is a still larger Barospirator capable of holding a patient, a physician, and a nurse. The operation of this larger instrument is in no sense different from the operation of the one shown diagrammatically in Figure 1, except for the addition of rather extensive arrangements for carbon dioxide absorption.

Now as to the actual operation of the Barospirator: The respiratory needs of man are such as to require a renewal of about one-sixth of the lung air sixteen times a minute. In the Barospirator this renewal is accomplished by a change in pressure and not in volume. The subject is locked in the chamber *A* and the motor *C* started. The lungs and respiratory system of the patient now correspond to the glass flask in our first illustration. Ventilation will be accomplished by rhythmic pressure differences between the air in the Barospirator and the air in the respiratory passages. "The situation is different from that presented by other methods of artificial respiration in that ventilation is attained without volume changes in the pulmonary air spaces." The lungs become an entirely passive part of the performance and the Barospirator chamber the active part.

The majority of persons placed in

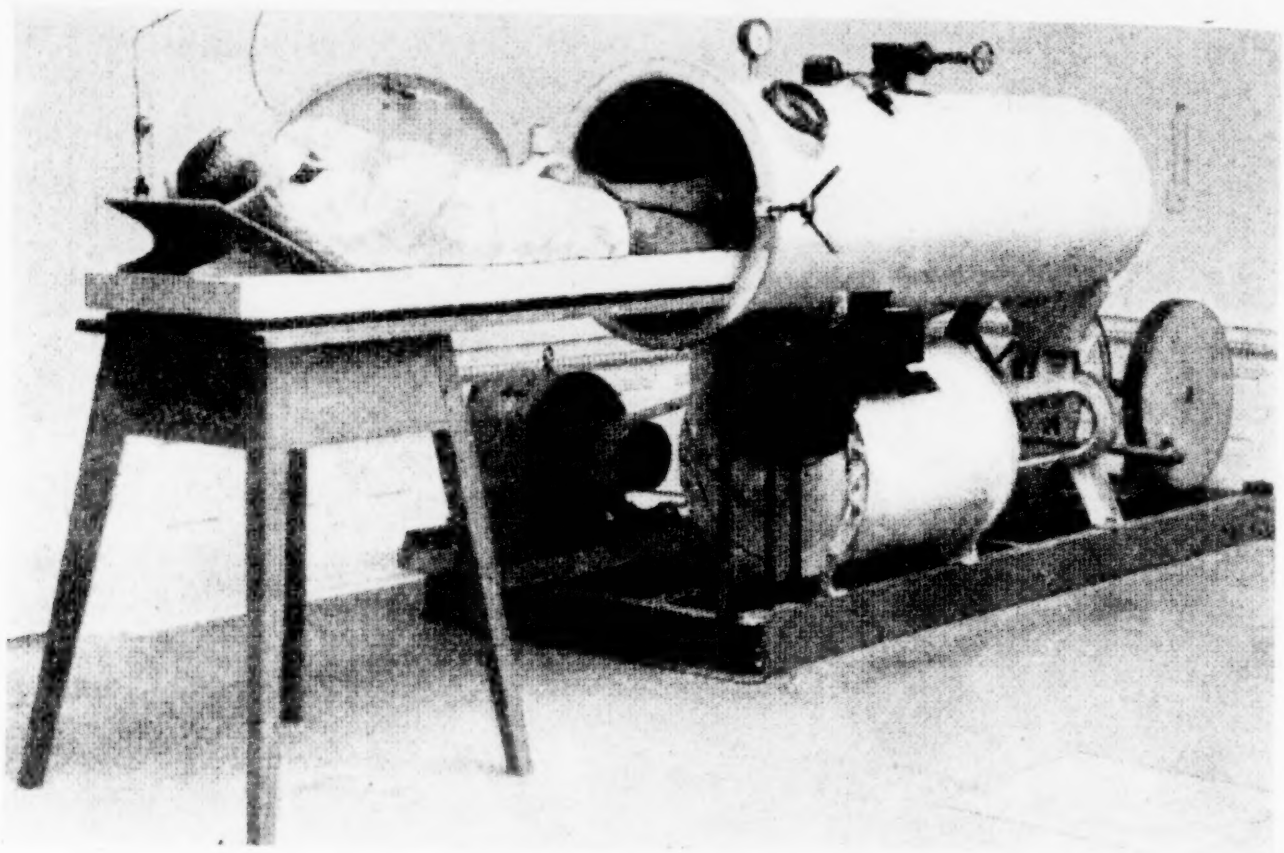

FIG. 2.—Photograph of Barospirator.

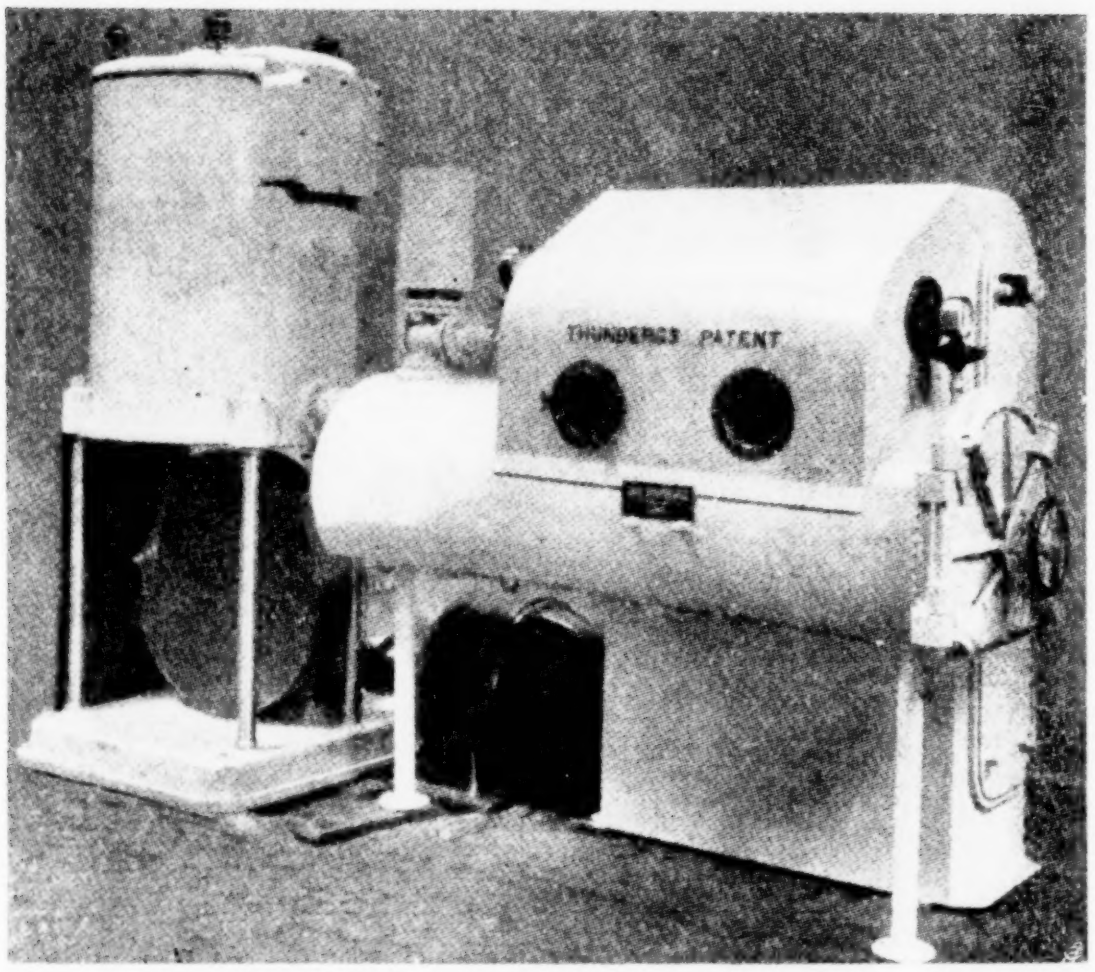

FIG. 3.—Photograph of large Barospirator capable of holding a patient, a physician, and a nurse.

the Barospirator soon lose all respiratory movements, as the setting of the instrument reaches a point meeting their respiratory needs. This apnea is what one must expect if pressure changes instead of volume changes begin to meet respiratory requirements. When some slight degree of breathing persists, it has no effect nor actual bearing on the efficiency of the Barospirator and the physiologic explanation of such cases is not clear.

In practical operation it is found that operation of the pump at a rate of 25 strokes a minute with a setting of the stroke so as to give pressure variations of ± 55 mm. Hg works well. When one enters the machine under such a setting, as the author had opportunity to do during the past summer, there are no subjective sensations other than those from the ears. The rapid rise and fall in pressure is at first unpleasant even if the mouth is held open, but one soon ceases to notice this annoyance and there is, of course, no possibility of harm from it.

It seems certain that the Barospirator can offer no danger to the patient. Pressures outside and inside the lungs are equal almost instantly, and even if the Barospirator is set to give unduly great changes in pressure, it is impossible to see how harm can be done.

Up to the present time the apparatus has had its most extensive use with normal subjects in order to gain a thorough body of normal experience, and this work is detailed most thoroughly in the monograph of Enghoff (9). Schmidt (10) has constructed a small apparatus, apparently exactly like the Barospirator, which he calls a "Wechseldruckkammer" and has shown, as might be expected, that the device works excellently in resuscitating cats poisoned by carbon monoxide. It is of course simple to keep the Barospirator filled with pure oxygen and thus to obtain the best circumstances for carbon monoxide removal. Petrén and Sjövall (11), under the title of "A Study of the Fatal Acute Form of Poliomyelitis," supply a report on the treatment of such a case in the Barospirator. A summary of this attempt at long-continued artificial ventilation is as follows:

A man 25 years old reported to the surgical clinic at 10 A.M. He was conscious but breathing with difficulty. All his respiratory muscles were apparently seriously involved. He was distinctly cyanotic, restless, and dyspneic. Pulse was 54. Very little paralysis of the legs was present but the arms and also the neck muscles were seriously involved. Swallowing was difficult and the voice weak. At 10:30, the patient was given 0.005 gm. of lobelin intravenously. At 11:18, he was placed in the Barospirator. At 11:35, his color was better and he was quiet. At 12, he was removed from the Barospirator. Asked whether he had felt better in the apparatus, he replied affirmatively. Pulse was 48 and of good quality. In a few minutes dyspnea and cyanosis became noticeable and the patient was quickly placed in the Barospirator once more.

The patient was treated in this way with occasional periods of removal for about fifty-one hours. For the first forty-eight hours he apparently did quite well, sleeping, taking nourishment, etc., but then he began to lose ground and after a short time died in the Barospirator. The cause of death after this long effort could not be ascertained. For forty-eight hours, during which no breathing occurred, barring the slight efforts which were made during the brief periods of withdrawal from the Barospirator, the patient's condition remained excellent and he even showed a certain amount of improvement. An autopsy showed that the cause of death was not an obstruction of the air passages, so that the work of the Barospirator did not fail through simple mechanical causes.

In a recent American experience a patient with Landry's palsy was kept alive for 108 hours by relays of men giving artificial respiration by the prone pressure method. Sleep is out of the question under such conditions and death from exhaustion must occur if spontaneous breathing is not resumed. The Barospirator, in that it permits sleep and rest and provides

respiration which is thoroughly adequate, offers the possibility of treating cases of respiratory failure heretofore unapproachable.

Barospirators must always be rather cumbersome affairs, and it is doubtful if they can have field use to any satisfactory degree. But this is unnecessary. One such appliance in a centrally situated hospital could care for the relatively few cases which actually require such prolonged treatment. It is usual instruction to advise continuing prone pressure artificial respiration for four hours—this for instances of electric shock, gas poisoning, and drowning. When it is evident that a long struggle is at hand, the patient can readily be brought to the Barospirator without interrupting artificial respiration and treatment can then be carried on by the apparatus. Outside of Lund in Sweden, such an opportunity is not as yet available, but the undoubted efficiency of the Barospirator makes it certain to come.

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QUANTITATIVE MEASUREMENTS OF THE INHALATION, RETENTION, AND EXHALATION OF DUSTS AND FUMES BY MAN: I. CONCENTRATIONS OF 50 TO 450 MG. PER CUBIC METER*

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INTRODUCTION

VARIOUS pathologic conditions result from the inhalation of certain types of particulate matter with particle size variations from the ultramicroscopic (less than 0.25 micron) up to about 18 microns. Hay fever is produced in susceptible subjects by the inhalation of the pollens of certain grasses and flowers (Fig. 1) (1), whose particles are sometimes as large as 18 microns; silicosis results from breathing, over extended periods, particles of silica of the order of 0.4 micron to 6 microns (2); dust containing coarser particles of lead (3), manganese (4), mercury (5), and the like are extremely toxic when inhaled; metal fume fever (6) results from the inhalation of finely divided metal fumes, like zinc oxide, with particles from 0.1 to 1 micron in size (Fig. 2), but apparently is not caused by breathing large particles of the order of those producing reactions in the case of hay fever and silicosis; finally, lead poisoning is acquired by breathing lead fume particles (7) about 0.5 micron or less in size.

The purpose of the experiments described in this paper was to determine quantitatively the amounts of representative dusts and fumes retained and expired by man when known amounts were breathed. This knowledge is of fundamental importance in working out the permissible or threshold concentrations of dangerous or toxic suspensions and seems to have been very nearly secured for silica dusts (8) and for zinc oxide fume (9) and to have been suggested for lead dusts (10). If thresholds for the common industrial dusts were known, specific ventilation requirements for the industries could more easily be arrived at. At the present time it is difficult to impose definite ventilation standards, because our knowledge of threshold dust concentrations is so largely hypothetical.

Since human subjects were used in these experiments, it was necessary to

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employ suspensions which simulated the finely divided dusts and fumes producing silicosis and lead and manganese poisoning, but which had not their dangerous qualities. Two types of zinc oxide were selected to represent the fumes—one was made by burning zinc and the second consisted of an exceptionally fine commercial zinc oxide powder, Kadox. For the dust experiments, we used marble from the Vermont quarries. Just how far our results on zinc oxide and marble can be applied to the retention of inhaled lead fume, inhaled silica, lead, or manganese dusts is problematic, but the physical analogies (those of particle size and dispersion) are reasonably close.

FIG. 1.—Pollen of giant ragweed (*Ambrosia trifida*), a common hay fever producing pollen. Particles shown are 18 microns in diameter. × 1500.

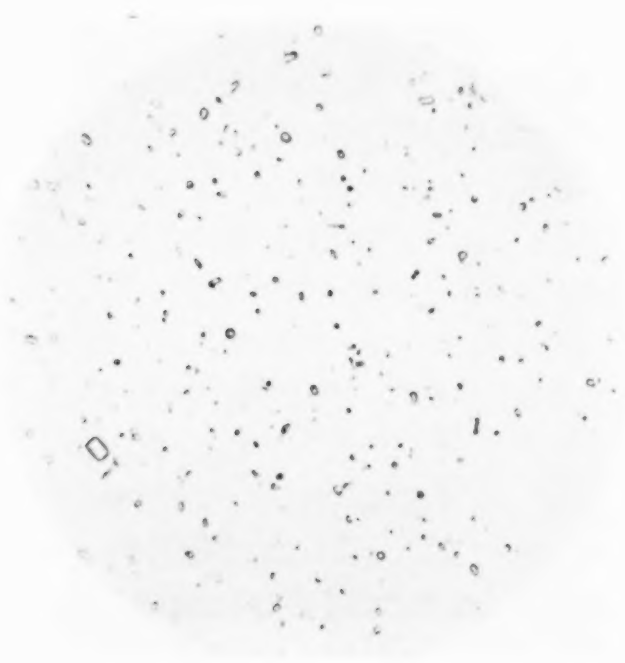

FIG. 2.—Zinc oxide from pot of molten brass. Particles are about 0.4 micron in size. × 1285.

GENERATION AND STABILITY OF THE SUSPENSIONS

Freshly formed zinc oxide suspensions (9) were made by blowing oxygen across the surface of zinc[1] heated to its approximate boiling temperature (930°C.) and allowing the fume clouds to escape into a 1,600 cubic foot gas cabinet (11). The actual fuming took about five minutes and uniform diffusion followed about twenty minutes later. We set up the second type of zinc oxide fume by drying Kadox[2] overnight at 110°C. and blowing the hot dried powder into the cabinet by means of a suction fee actuated by compressed air. Fans were not used for either type of zinc oxide suspension, as satisfactory diffusion and dispersion were accomplished without them.

The setting up of uniform suspensions of marble dust presented greater difficulty, for grinding and screening will not produce particles of the uniformity and fineness of fume particles.

[1] This was 99.92 per cent. zinc (6) giving oxide particles about 0.4 micron.

[2] This was 99.4 per cent. zinc oxide (12) with particles about 0.15 micron. Both the metallic zinc and the Kadox were furnished by the New Jersey Zinc Company, Palmerton, Pa.

The finest Tyler sieve we were able to obtain had 325 meshes to the linear inch, or openings of about 42 microns. The ground marble[3] was first passed through this screen. It was then dried overnight at 110°C. and blown into the cabinet by the suction tee method. During the dusting, oscillating fans controlled from without were run within the cabinet for about four minutes. At least twenty minutes were then allowed for the large particles and flocculates to settle out. The photomicrograph in Figure 3 is evidence that the large particles were not contained in the air breathed in the experimental inhalations. As a further check on the method, we made fractional settlings in water, using 1,000 c.c. graduates, and found that marble dust particles with a median size of 62 microns settled within two minutes, those of 15 microns within thirty minutes, and those of 2.5 microns within four days. Photomicrographs of these three fractions are shown in Figure 4. As the settling rate in still air is very much more rapid than in water, the twenty-minute interval allowed for the settlement of large particles seems adequate.

Whether the suspension is 1-micron dust or 0.15-micron fume, the rate of settlement of the particles must be considered in determining the concentration breathed during the experiments. The concentration breathed by subject F (Fig. 5), for example, dropped off about 12 per cent. in the course of his fifteen-minute inhalation. In order to take this decrease into account, we assumed

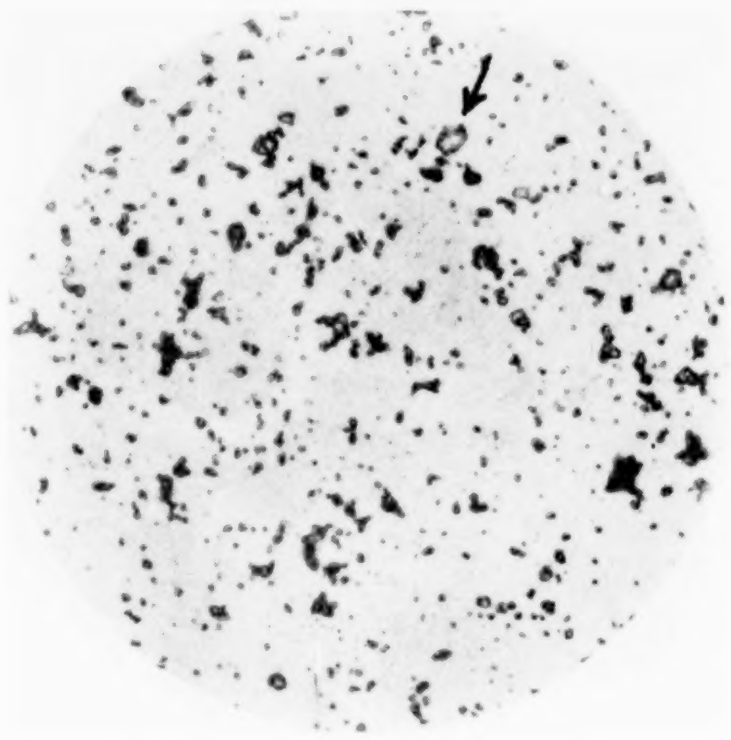

FIG. 3.—Marble dust breathed in these experiments. Particles varied from about 0.3 micron to 6 microns. The dust photographed was caught by electric precipitator (13) on celluloid foil and photographed dry. Arrow points to particle 4.5 microns in size. × 500.

that the duration of each experiment was represented by a straight line on the curve and that the subject breathed an average concentration represented by a point midway between the concentration at the beginning and that at the end of his experiment.

APPARATUS USED IN INHALATION EXPERIMENTS

The apparatus and set-up used in the inhalation and retention experiments is shown in Figure 6. The subject, seated at rest, breathed a suspension of known concentration through the facepiece of a Kops type gas mask. The concentration inhaled was estimated by Tyndallmeter (14) and by electric precipitator (13) from the atmosphere in the cabinet. The

[3] The 325-mesh marble dust contained 2.4 per cent. of acid insoluble matter, 0.1 per cent. of moisture, and 85.7 per cent. of calcium carbonate. Furnished by Dr. J. U. Gardner, Trudeau Sanatorium, Saranac Lake, N. Y.

subject's exhalations passed through another precipitator and thence to a large spirometer. This precipitator caught the exhaled particles (which could then be quantitatively estimated) and the spirometer measured the volume of air breathed.

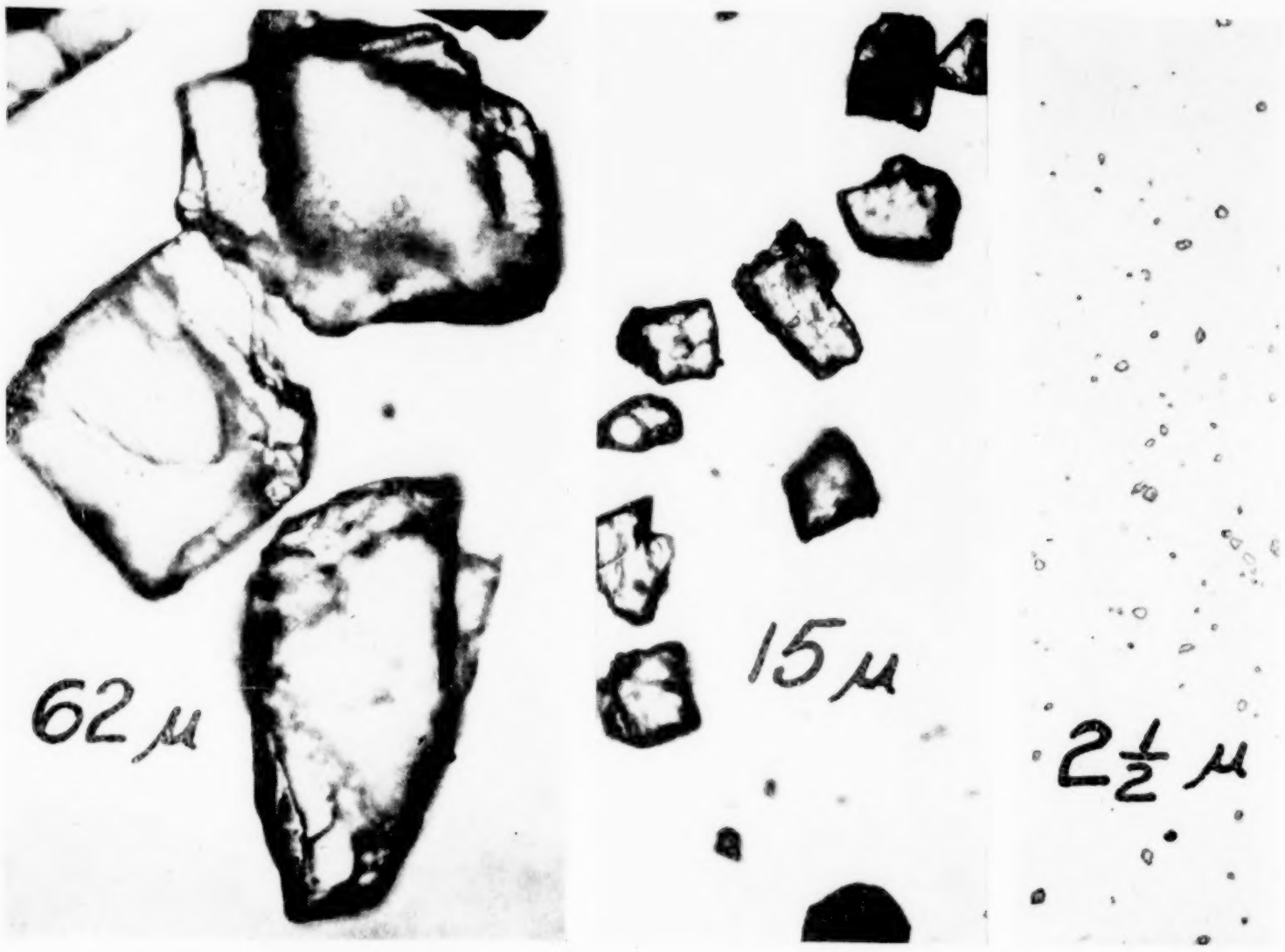

FIG. 4.—Particles of marble dust separated into different groups according to size by repeated settlings in water. × 500.

QUANTITATIVE ESTIMATION OF INHALED AND EXHALED DUSTS AND FUMES

The total amounts of zinc oxide and of marble in the inhaled and exhaled air were estimated by means of the electric precipitator. In determining the concentration of the suspension in the air of the cabinet (*i.e.*, the air inhaled), we took at least three samples by precipitator and six by Tyndallmeter, the one method serving as a check on the other. In the case of the marble dust, the suspension was so coarse that the Tyndallmeter was of little use and we relied solely on the precipitator samples for establishing the settling curves.[4] The curves thus drawn were generally smooth and regular, of the type shown in Figure 5. The occasional experiments resulting in irregular curves were discarded.

From the mean value taken from the settling curve (Fig. 5) we subtracted the material collected along the glass tubing and in the rubber valve leading to the mask. In like manner, we added the suspension collected in the apparatus between the

[4] For dense suspensions of finer dust, the Tyndallmeter is very useful, however.

mask and the precipitator to that collected in the precipitator itself (Fig. 6). These losses on both sides of the mask were always significant, no matter what type of suspension was used or what its concentration happened to be. In addition to these corrections, we took into account any chemical impurities in the rubber valves and rubber tubing which might affect the results.

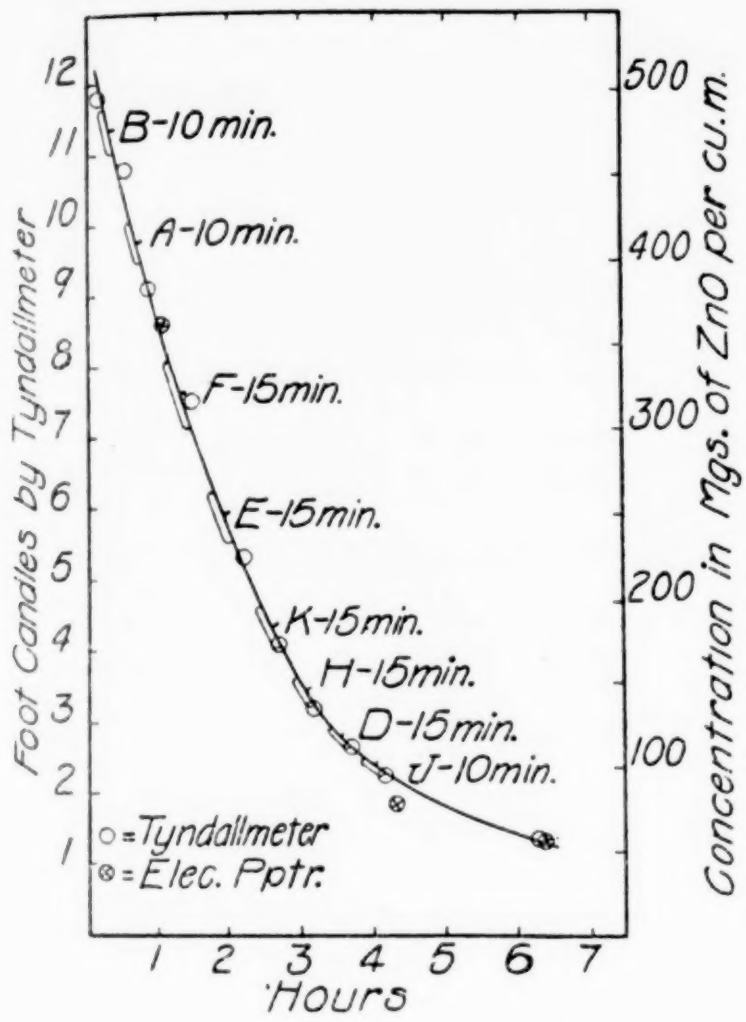

FIG. 5.—Inhalation experiments plotted on a typical settling curve for freshly generated zinc oxide fume. Brackets on the curve indicate the actual time and duration of each inhalation experiment.

The zinc oxide estimations were made by dissolving the oxide in a known amount of 0.1 N sulphuric acid and titrating with potassium ferrocyanide, according to Fairhall's procedure (15). The marble dust precipitates were dissolved in 0.1 N hydrochloric acid, the calcium was precipitated as the oxalate, ignited to convert to the oxide, then dissolved in a known amount of hydrochloric acid, and titrated with 0.01 N alkali.

QUANTITATIVE ESTIMATION OF DUSTS AND FUMES RETAINED

Table 1 gives the data from sixteen experimental inhalations of freshly formed zinc oxide, Table 2 the data from nine Kadox inhalations, and

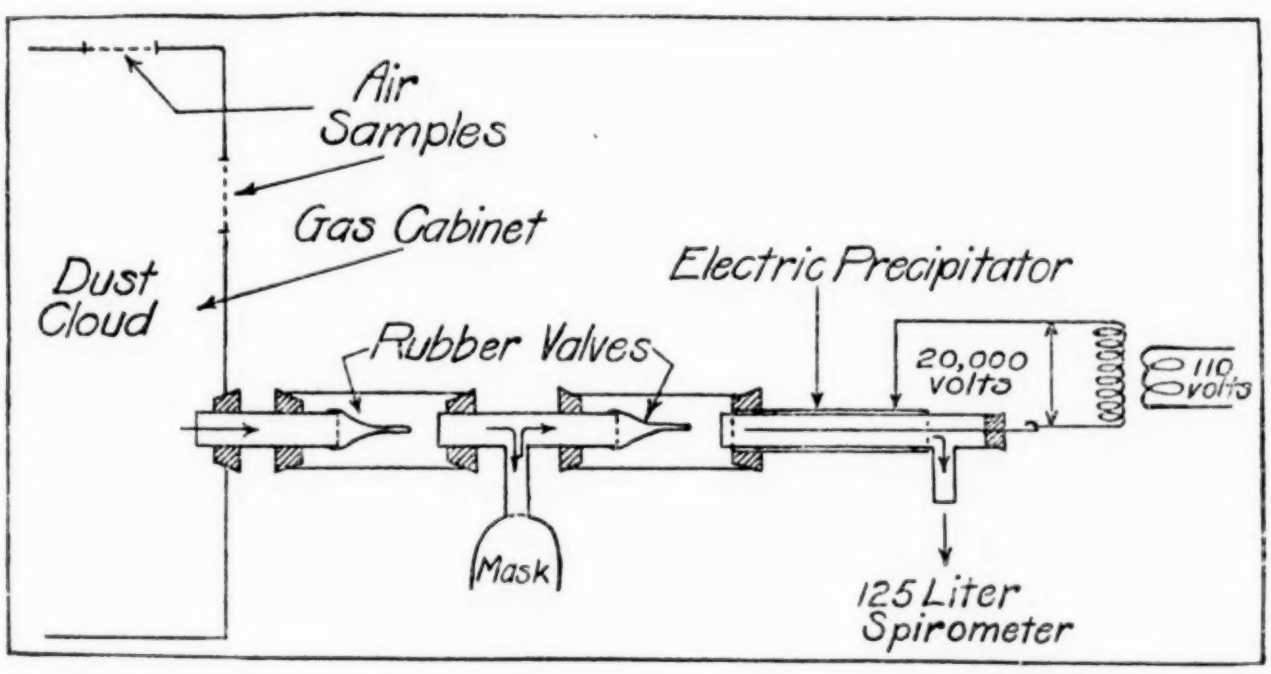

FIG. 6.—Apparatus used for determining the inhalation, retention, and expiration of dusts and fumes (9). The spirometer is equipped with a large three-way inlet cock and was emptied and filled at least twice during forty-minute experiments.

TABLE 1.—CONCENTRATIONS AND PERCENTAGE RETENTIONS OF ZINC OXIDE FUME

EXPERIMENT	VITAL CAPACITY	I CONCENTRATION OF ZINC OXIDE INHALED	II EXPOSURE	III RESPIRATIONS PER MINUTE	IV TOTAL AIR BREATHED	V IV ÷ II MINUTE-VOLUME	VI IV × 1/1000 TOTAL ZINC OXIDE INHALED	VII TOTAL ZINC OXIDE EXHALED	VIII VI − VII TOTAL ZINC OXIDE RETAINED	IX VIII ÷ VI/100 RETAINED
	l.	*mg./cu.m.*	*min.*		*l.*	*l.*	*mg.*	*mg.*	*mg.*	%
Subject A, aged 32, M.										
1	6.1	31	40	6	264	6.6	8.2	4.7	3.5	43
2		65	20	6	176	8.8	11.4	3.2	8.2	72
3		419	5	10	49	9.8	20.5	11.3	9.2	45
4		92	7	10	73	10.4	6.7	4.1	2.6	39
Subject B, aged 38, M.										
5	4.4	364	5	10	42	8.4	15.2	7.4	7.8	51
6		422	5	9	41	8.2	17.3	5.1	12.2	70
Subject D, aged 30, M.										
7	4.5	163	5	17	51	10.2	8.3	3.0	5.3	64
8		346	5	18	66	13.2	22.8	8.8	14.0	61
Subject J, aged 28, F.										
9	2.5	258	5	9	55	11.0	14.2	5.2	9.0	63
10		428	5	12	51	10.2	21.8	6.7	15.1	69
Subject L, aged 37, M.										
11	4.3	311	5	10	53	10.6	16.5	8.4	8.1	49
12		163	5	8.5	49	9.8	8.0	3.2	4.8	60
Subject M, aged 20, M.										
13	3.7	273	5	13	52	10.4	14.3	7.5	6.8	48
Subject N, aged 36, M.										
14	4.7	108	4	17	37	9.3	4.0	2.3	1.7	43
Subject O, aged 28, M.										
15	4.7	194	5	17	66	13.2	12.8	4.0	8.8	69
16		83	8	12	109	13.6	9.0	3.5	5.5	61
Mean										57
Standard Deviation										10.8

TABLE 2.—CONCENTRATIONS AND PERCENTAGE RETENTIONS OF ZINC OXIDE POWDER (KADOX)

EXPERIMENT	VITAL CAPACITY	I CONCENTRATION OF ZINC OXIDE INHALED	II EXPOSURE	III RESPIRATIONS PER MINUTE	IV TOTAL AIR BREATHED	V IV ÷ II MINUTE-VOLUME	VI IV × 1/1000 TOTAL ZINC OXIDE INHALED	VII TOTAL ZINC OXIDE EXHALED	VIII VI − VII TOTAL ZINC OXIDE RETAINED	IX VIII ÷ VI/100 RETAINED
	l.	*mg./cu.m.*	*min.*		*l.*	*l.*	*mg.*	*mg.*	*mg.*	%
Subject A, aged 32, M.										
17	6.1	263	5	11	56	11.2	14.7	5.7	9.0	61
18		74	40	13	455	11.4	33.5	14.0	19.5	58
Subject B, aged 38, M.										
19	4.4	93	20	9	149	7.5	13.9	5.2	8.7	63
Subject D, aged 30, M.										
20	4.5	221	6	15	67	11.1	14.8	6.8	8.0	54
21		104	10	16	94	9.4	9.8	4.1	5.7	58
Subject J, aged 28, F.										
22	2.5	189	7	9	65	9.3	12.3	5.5	6.8	55
23		198	6	10	64	10.7	12.7	4.3	8.4	67
Subject O, aged 28, M.										
24	4.7	162	5	15	71	14.2	11.6	6.9	4.7	41
Subject P, aged 44, M.										
25	4.4[1]	140	5	7	39	7.8	5.5	2.8	2.7	49
Mean										56
Standard Deviation										7.3

[1] Estimated according to West (16).

TABLE 1.—CONCENTRATIONS AND PERCENTAGE RETENTIONS OF ZINC OXIDE FUME

EXPERIMENT	VITAL CAPACITY	I CONCENTRATION OF ZINC OXIDE INHALED	II EXPOSURE	III RESPIRATIONS PER MINUTE	IV TOTAL AIR BREATHED	V IV ÷ II MINUTE-VOLUME	VI IV × 1/1000 TOTAL ZINC OXIDE INHALED	VII TOTAL ZINC OXIDE EXHALED	VIII VI − VII TOTAL ZINC OXIDE RETAINED	IX VIII ÷ VI/100 RETAINED
	l.	*mg./cu.m.*	*min.*		*l.*	*l.*	*mg.*	*mg.*	*mg.*	*%*
Subject A, aged 32, M.										
1	6.1	31	40	6	264	6.6	8.2	4.7	3.5	43
2		65	20	6	176	8.8	11.4	3.2	8.2	72
3		419	5	10	49	9.8	20.5	11.3	9.2	45
4		92	7	10	73	10.4	6.7	4.1	2.6	39
Subject B, aged 38, M.										
5	4.4	364	5	10	42	8.4	15.2	7.4	7.8	51
6		422	5	9	41	8.2	17.3	5.1	12.2	70
Subject D, aged 30, M.										
7	4.5	163	5	17	51	10.2	8.3	3.0	5.3	64
8		346	5	18	66	13.2	22.8	8.8	14.0	61
Subject J, aged 28, F.										
9	2.5	258	5	9	55	11.0	14.2	5.2	9.0	63
10		428	5	12	51	10.2	21.8	6.7	15.1	69
Subject L, aged 37, M.										
11	4.3	311	5	10	53	10.6	16.5	8.4	8.1	49
12		163	5	8.5	49	9.8	8.0	3.2	4.8	60
Subject M, aged 20, M.										
13	3.7	273	5	13	52	10.4	14.3	7.5	6.8	48
Subject N, aged 36, M.										
14	4.7	108	4	17	37	9.3	4.0	2.3	1.7	43
Subject O, aged 28, M.										
15	4.7	194	5	17	66	13.2	12.8	4.0	8.8	69
16		83	8	12	109	13.6	9.0	3.5	5.5	61
Mean										57
Standard Deviation										10.8

TABLE 2.—CONCENTRATIONS AND PERCENTAGE RETENTIONS OF ZINC OXIDE POWDER (KADOX)

EXPERIMENT	VITAL CAPACITY	I CONCENTRATION OF ZINC OXIDE INHALED	II EXPOSURE	III RESPIRATIONS PER MINUTE	IV TOTAL AIR BREATHED	V IV ÷ II MINUTE-VOLUME	VI IV × 1/1000 TOTAL ZINC OXIDE INHALED	VII TOTAL ZINC OXIDE EXHALED	VIII VI − VII TOTAL ZINC OXIDE RETAINED	IX VIII ÷ VI/100 RETAINED
	l.	*mg./cu.m.*	*min.*		*l.*	*l.*	*mg.*	*mg.*	*mg.*	%
Subject A, aged 32, M.										
17	6.1	263	5	11	56	11.2	14.7	5.7	9.0	61
18		74	40	13	455	11.4	33.5	14.0	19.5	58
Subject B, aged 38, M.										
19	4.4	93	20	9	149	7.5	13.9	5.2	8.7	63
Subject D, aged 30, M.										
20	4.5	221	6	15	67	11.1	14.8	6.8	8.0	54
21		104	10	16	94	9.4	9.8	4.1	5.7	58
Subject J, aged 28, F.										
22	2.5	189	7	9	65	9.3	12.3	5.5	6.8	55
23		198	6	10	64	10.7	12.7	4.3	8.4	67
Subject O, aged 28, M.										
24	4.7	162	5	15	71	14.2	11.6	6.9	4.7	41
Subject P, aged 44, M.										
25	4.4[1]	140	5	7	39	7.8	5.5	2.8	2.7	49
Mean										56
Standard Deviation										7.3

[1] Estimated according to West (16).

TABLE 3.—CONCENTRATIONS AND PERCENTAGE RETENTIONS OF MARBLE DUST

EXPERIMENT	VITAL CAPACITY	I CONCENTRATION OF MARBLE INHALED	II EXPOSURE	III RESPIRATIONS PER MINUTE	IV TOTAL AIR BREATHED	V IV ÷ II MINUTE-VOLUME	VI IV × 1/1000 TOTAL MARBLE INHALED	VII TOTAL MARBLE EXHALED	VIII VI − VII TOTAL MARBLE RETAINED	IX VIII ÷ VI/100 RETAINED
	l.	*mg./cu.m.*	*min.*		*l.*	*l.*	*mg.*	*mg.*	*mg.*	%
Subject A, aged 32, M.										
26	6.1	103	10	13	116	11.6	12.0	5.7	6.3	53
27		231	7	11	85	12.1	19.6	9.5	10.1	52
28		219	9	13	117	13.0	25.6	9.7	15.9	62
29		89	25	12	271	10.8	24.1	15.6	8.5	36
30		144	7	6	66	9.4	9.5	5.0	4.5	47
31		61	20	12	215	10.8	13.2	5.7	7.5	57
Subject B, aged 38, M.										
32	4.4	332	7	11	59	8.4	19.6	5.8	13.8	70
Subject C, aged 40, M.										
33	4.1	147	6	10	66	11.0	9.7	3.5	6.2	64
34		200	9	9½	78	8.7	15.6	8.2	7.4	47
Subject D, aged 30, M.										
35	4.5	196	5	16	54	10.8	10.6	3.9	6.7	63
36		119	9	6	75	8.3	8.9	3.2	5.7	64
Subject J, aged 28, F.										
37	2.5	122	10	15	105	10.5	12.8	7.2	5.6	44
38		137	6	15½	51	8.5	7.0	3.4	3.6	51
39		190	15	14	118	7.9	22.4	11.9	10.5	47
40		146	15	16	158	10.5	23.0	11.8	11.2	48
41		115	15	6	93	6.2	10.7	3.6	7.1	66
Mean										54
Standard Deviation										9.2

Table 3 the data from sixteen inhalations of marble dust. The percentage retentions are shown graphically in Figures 7, 8, and 9, respectively. From the tables it will be seen that various rates of breathing, concentrations, and lengths of exposure were employed, and it is of interest to notice that these variations produced no significant differences in the percentage retentions. The mean figures (percentages) for freshly generated zinc oxide (particles 0.4 micron) were 57 ± 10.8, for Kadox (particles 0.15 micron) 56 ± 7.3, and for marble (particles 0.3 micron to 6 microns) 54 ± 9.2. It will be seen that, in spite of the difference in particle size, the percentage retentions for the three suspensions were very like. Since the differences are less than our experimental error, it seems reasonable to average the results; this gives a general percentage retention of 55 ± 9.4.

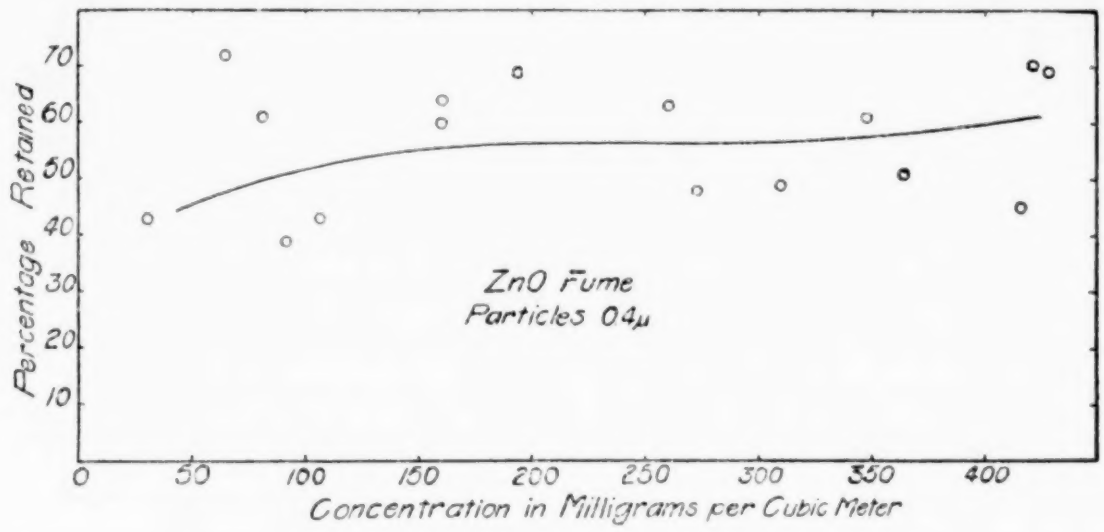

FIG. 7.—Concentrations and percentage retentions of zinc oxide fume (from Table 1).

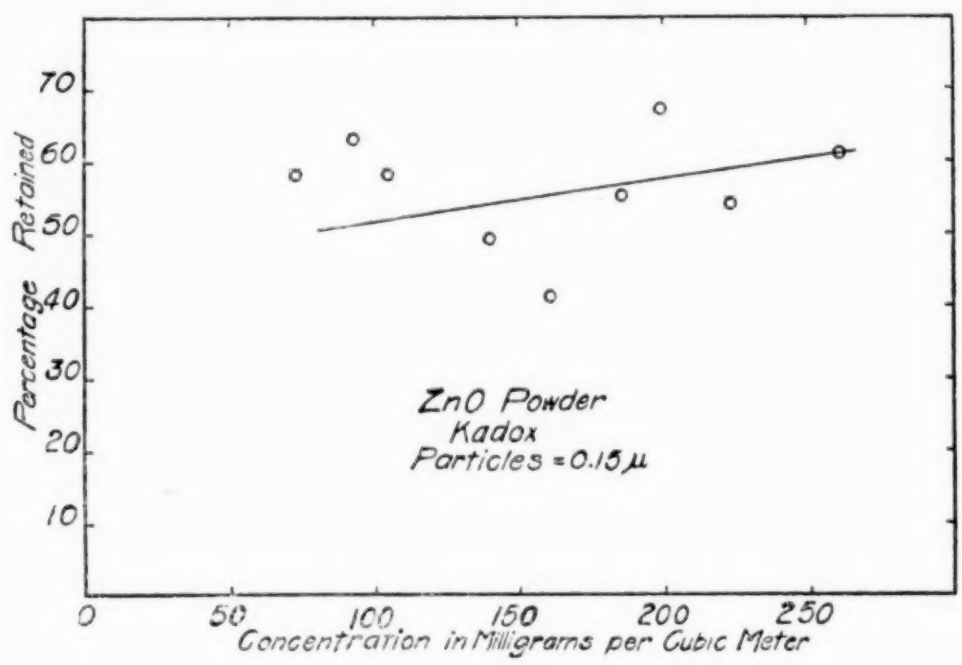

FIG. 8.—Concentrations and percentage retentions of zinc oxide powder (Kadox) (from Table 2).

We believe that the scattering of the points in the plots of percentage retentions was due to the subjects' inability to breathe in precisely the same way on successive occasions, rather than to errors or to experi-

mental inaccuracies in dust estimations. Experienced subjects like A always had more uniform minute-volumes than new subjects. It does not necessarily follow, however, that the uniform rates of breathing are physiologically more reliable than the nonuniform performances of less experienced subjects.

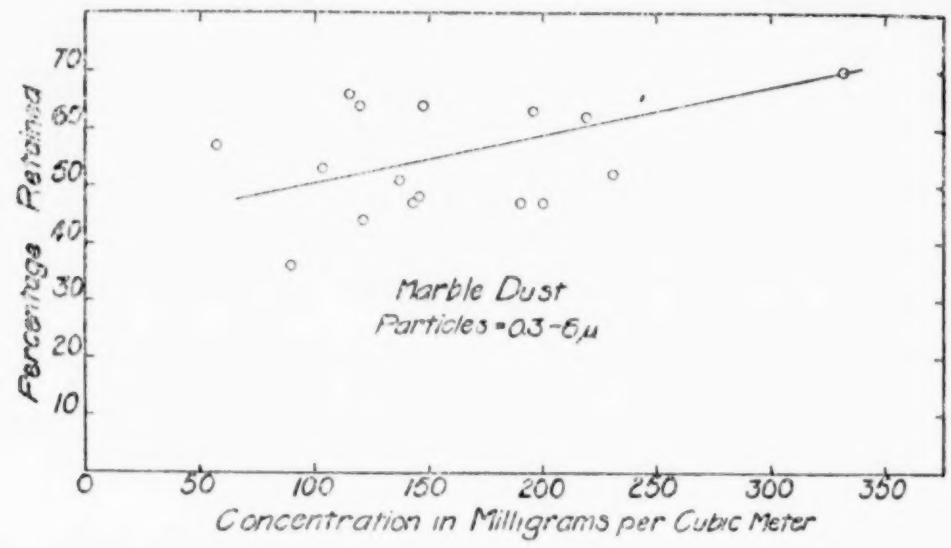

FIG. 9.—Concentrations and percentage retentions of marble dust (from Table 3).

Of the three percentage retention curves, Figures 7, 8, and 9, that for freshly formed zinc oxide (Fig. 7) is probably the most reliable. We had had some two years' experience with this substance and consequently it presented the fewest experimental difficulties. As might be expected, there is a tendency for percentage retentions to vary with concentration, but it seems improbable that they ever fall below about 20 per cent. or rise much above 80 per cent.

DISCUSSION

To our knowledge, three previous studies have been made on this particular aspect of the dust problem. In 1912, Lehmann, Saito, and Gfrörer (17) studied the quantitative and percentage retention by man of white lead dust, when known concentrations were breathed. When the subject inhaled and exhaled through the mouth, they estimated that 6 per cent. was exhaled, 15 per cent. caught in the oral cavity, and about 79 per cent. lodged in the lungs. With nose breathing, they found that 50 per cent. remained in the nasal passages, about 3 to 10 per cent. was exhaled, and the remainder caught in the lungs.

The reason why their retentions (generally over 90 per cent.) are so much higher than ours (about 55 per cent.) is probably because their dust cabinet was very small. During ten-minute to fifteen-minute experiments like theirs, dust had to be supplied intermittently or continually to the cabinet. In our experience, such procedure always results in the presence of clumps and flocculates of dust particles, which are caught and retained more easily than well-dispersed particles. With the dense concentrations they used (no information on particle size or dispersion is given), nasal breathing is very effective in preventing penetration of dust to the lungs, and they found that frequent nasal and mouth rinsings removed a considerable portion of the dust which

would otherwise have been swallowed. Under the conditions of our experiments (uniform suspensions of particles 0.15 micron to 6 microns in size with no large clumps or flocculates present), we found no significant advantage in nasal over mouth breathing. It must not be thought that our results contradict theirs, for our conditions were too different for a direct comparison. We believe, however, that the conditions under which our experiments were performed are representative of conditions of daily dust inhalation in industry.

Baumberger's studies (18) on tobacco smoke suggested to us the use of the electric precipitator instead of the filter for estimating the dust in expired air. The disadvantage of the filter method, which was employed by Lehmann and his co-workers, is that efficient filters offer enough resistance to air flow to cause annoyance to the subject. Baumberger's results with the precipitator on tobacco smoke indicated retentions of 67 per cent. in "puffing" and 88 per cent. in "inhaling" cigarette smoke. The fact that these figures are so much higher than ours may be due both to the difference in the methods used and to the difference in the suspensions. Baumberger's subjects performed two separate series of experiments. In one, they drew cigarette smoke (wet, oily particles) through a precipitator in which the smoke was caught before it reached them. In the second series they either puffed or inhaled and then exhaled through a precipitator, the exhaust side of which was under a slight negative pressure. The average amounts caught in the first and in the second series were then used to determine percentage retentions. As a result, the deviations from the mean values were very large, as Baumberger pointed out. We endeavored to avoid this difficulty by inhaling known concentrations of dry suspensions and collecting the entire amount expired.

Sayers, Fieldner, and their associates (19) found 15 per cent. retentions in the breathing of very low concentrations of lead compounds given off in the diluted gases from an internal combustion engine burning ethyl gasoline.[5] So far as one can judge from their brief description, our set-up and procedure was much like theirs, although they make no reference to losses of suspension throughout their inhalation apparatus, losses which we found too great to be ignored, no matter what material we used and in what concentration. Their concentrations (about 0.07 to 0.25 mg. of lead per cubic meter) were very much lower than any we used, which may account for their lower percentage retentions.

Largely as the result of the South African work on quartz dust, 5 mg. per cubic meter by sugar tube is often mentioned as the South African standard of permissible dustiness. From the field studies of the United States Bureau of Mines and the United States Public Health Service, as well as from more limited studies by others, 5 mg. per cubic meter seems a much lower concentration than is found, under average conditions, in dusty industries in the United States.

[5] Three c.c. of tetraethyl lead and 2 c.c. of ethylene dibromide or trichlorethylene were added to each gallon (U. S.) of gasoline to make "ethyl" gasoline. The gases breathed were diluted with enough air to obviate the carbon monoxide hazard.

We believe that the concentrations we have used in these experiments are more fairly representative of average American "dusty" conditions.

We are continuing this study to cover concentrations of 0.5 mg. to 50 mg. per cubic meter and shall publish our results in a future paper.

Summary

Suspensions of freshly generated zinc oxide fume (particles about 0.4 micron), of Kadox (a zinc oxide powder with particles about 0.15 micron), and of marble dust (particles about 0.3 to 6 microns) were set up in a 1,600 cubic foot gas cabinet. The subjects, seated outside the cabinet, inhaled the air from within and exhaled through an electric precipitator into a 125-liter spirometer.

Details of forty-one experiments are given in tables and graphs, showing the amounts inhaled, exhaled, and retained by normal men and women. Various concentrations, lengths of exposure, and rates of breathing were used. The percentage retentions for all three suspensions averaged 55 with a standard deviation of 9.4. The concentrations inhaled varied from about 50 to 450 mg. per cubic meter, the exposures from five to forty minutes, and the rates of breathing from 6 to 18 respirations per minute.

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BOOK REVIEWS

Körper und Arbeit. Handbuch der Arbeitsphysiologie. Edited by Prof. Dr. *Edgar Atzler*, Direktor des Kaiser-Wilhelm-Instituts für Arbeitsphysiologie, Berlin. Paper. Pp. xii, 770 with illustrations and indexes. Leipzig: Georg Thieme, 1927.

This comprehensive work edited by the director of the Kaiser Wilhelm Institute for the Study of the Physiology of Work has been written by numerous competent contributors. It consists of fifteen well-illustrated chapters, each with its own bibliography. The first, as one would anticipate, deals with the functional anatomy of human muscles, being contributed by Dr. Karl Peter of Greifswald. It is clear, concise, and well illustrated. The second chapter, on the physiology of muscle, by Dr. Otto Riesser is less adequate than the other portions of the work. The problems of energy exchange in muscles, however, and of the balance sheet of Hill and Meyerhof, are clearly summarized and provide for those who have not followed the recent developments in this field a brief and accurate statement of the present state of knowledge. One feels, however, that undue emphasis is placed upon the rôle of phosphoric acid in muscular contraction, the subject being dealt with at length when all too little is known to warrant dogmatic statements. Riesser wisely avoids any definite statements concerning the nature of muscle tonus.

One is somewhat surprised to find a long chapter on the sense organs in a monograph devoted to the physiology of work; however, the subject, which is contributed by G. Lehmann of Berlin, is well summarized. This chapter has appended to it a section on the anatomy and physiology of the nervous system which naturally suffers

from altogether too great condensation, and one questions the wisdom of including such material in a work of this scope.

In the admirable chapter by René du Bois-Reymond on the mechanical principles involved in the movements of the human body, one finds several lucid paragraphs on static work and the mechanics of standing, points too little studied in general physiology. A most useful chapter is that of Ernst Mangold on circulation and respiration of muscles. In this is gathered together a great variety of material not elsewhere available which will be welcomed by all students of muscle physiology. Particularly valuable is his discussion of the relation of local circulation rate to muscle metabolism. There is also an admirable chapter on the thermodynamics of muscles by the editor.

Probably the most valuable contributions are the chapters by Arnold Durig of Vienna on the theory and practical significance of muscle fatigue considered in relation to the problem of industrial fatigue. This is undoubtedly the most complete and scholarly presentation of the subject of fatigue to be found in any language. Both chapters contain exhaustive bibliographies. It is, however, regrettable that Professor Durig was not able to avail himself of the recent studies of Professor Collis of Cardiff who lately has published the results of his war experience. Professor Durig emphasizes the importance of short hours and of frequent change in the nature of the worker's muscular performance. More and better work can be done in eight hours than in ten, especially if the occupation is varied.

The last hundred pages of the book deal with the hygiene and the clothing of the workers, and include a section on the living conditions of industrial laborers and a chapter on the relation of sports to physical work.

Professor Atzler's book is a noteworthy contribution and its value lies not alone in its useful and able summaries but also in its original point of view which is certain to stimulate research. It is well printed and is provided with both author and subject indexes.—*J. F. Fulton.*

PERSONAL HEALTH. By *Emery R. Hayhurst*, A.B., A.M., M.D. (Illinois), Ph.D. (Chicago), Professor of Hygiene and Chairman of the Department of Public Health in the Ohio State University; Consultant in Industrial Hygiene to the Ohio State Department of Health; Etc. Co-editor "Industrial Health" (1924) with Dr. George M. Kober; Author, "Occupational Diseases"—Craig's "Diseases of Middle Life" (1923); "Industrial Health Hazards and Occupational Diseases in Ohio" (1915); Etc.; Editorial Committee, American Journal of Public Health; Associate Editor, Journal of Industrial Hygiene; Etc. First edition. Cloth. Pp. 279 with index. New York and London: McGraw-Hill Book Company, Inc., 1927.

The author's purpose, as stated in his preface, is as follows: "'Personal Health' is written to meet the demand for a small, practical book that will serve the busy person in shop or office as a health guide and medical adviser."

In 267 pages of text, the book treats in popular style of the basic facts of physiology, hygiene, therapeutics, pathology, and bacteriology. The task of adequately covering so extensive a field in the space and manner indicated is not an enviable one and the book inevitably suffers from brevity and incompleteness.

In the reviewer's opinion, reference books like Dr. Hayhurst's admirable

work on "Industrial Health" and periodicals like *Hygeia* better fulfil the purpose for which this book was intended.—*Philip Drinker.*

DER ELEKTRISCHE UNFALL. Skizziert für Ingenieur und Arzt. By Prof. Dr. med. *Stefan Jellinek*, Honorardozent an der Technischen Hochschule in Wien. Second, enlarged edition. Cloth. Pp. 170 with illustrations and index. Leipzig and Vienna: Franz Deuticke, 1927.

In this, his second edition of his work on the electric accident, Professor Jellinek has rewritten, and to some extent enlarged on, the subject matter of the first edition. The new material consists mainly in a study of the more rare forms of electric accident, namely, those encountered in the use of the radio and the X-ray.

Professor Jellinek approaches the subject by pointing out that the electric accident is by virtue of its unique character different from the ordinary industrial accident and should, therefore, be the subject of special study. Great care should be exercised in the reporting of these accidents and a very complete examination made in each case. Accidents are divided into three groups which he calls: (1) verified accidents; (2) verifiable accidents; and (3) unverified accidents. The characteristics and differentiating points of each group are given. Many pitfalls into which the unwary investigator may fall are uncovered. Much space is devoted to reports of accidents which show the diversified conditions and materials that may be involved and it is seen that there is no one physical or electrical constant present in every case. While it is credible that, in addition to the questions of current strength, contact, etc., the physical condition of the victim may be of importance, the author's contention that the mental attitude, or state of preparedness, is of perhaps greater importance, is not considered proved.

Further cases are recorded to illustrate the sensations experienced by the electrocuted person both during and, should he survive, after the passage of the current. While detailed accounts are given of the various manifestations of the passage of the current through various tissues and the nature of the pathologic changes seen therein, some attempt is made to explain these changes as the resultant of two factors: (1) the passage of the electricity, and (2) the propagation of the excitation due to the electric discharge.

A chapter is devoted to the treatment of the electric injury and it is to be noted that the author advocates only conservative measures.

The question of apparent death is discussed fully. Where death does occur, it usually falls into one of four groups: (1) sudden instantaneous death; (2) retarded death; (3) interrupted death; and (4) delayed death (after apparent recovery). These well-defined types of death appear to be the result of functional disturbances in themselves the resultant of some unknown combination of conditions and circumstances at the time of the accident. This, in the author's opinion, is borne out by the autopsy findings and by the variable results of resuscitative measures.

Finally, rescue technic for use in electric accidents is thoroughly discussed and an ideal established for rescue measures. The Silvester method of artificial respiration accompanied

by traction on the tongue is adopted in contrast to the prone pressure method—the method of choice in the United States and Canada. The fact is stressed that artificial respiration must be started at once, must not be discontinued even momentarily, and should be continued until either success or *rigor mortis* occurs. Professor Jellinek has produced a remarkable monograph on the subject of the electric accident, but the fundamental principles of the nature of the action of the electric current have yet to be explained.—*R. W. Ian Urquhart.*

NOXIOUS GASES AND THE PRINCIPLES OF RESPIRATION INFLUENCING THEIR ACTION. By *Yandell Henderson* and *Howard W. Haggard*. From the Laboratory of Applied Physiology, Sheffield Scientific School, Yale University. American Chemical Society Monograph Series, No. 35. Cloth. Pp. 220 with index. New York: Chemical Catalog Co., Inc., 1927.

This book is a substantial effort to supply chemists, engineers, and others engaged in industry with the information necessary to understand something of the action of poisonous gases and the rationale of treatment. It is of course impossible to convey such a message without indulging in some rather complicated physiology.

The first five chapters are given to the task of making modern respiratory physiology assimilable for men whose training in anatomy and biology is slight. The authors seem to have accomplished this both briefly and clearly. No doubt the reader, innocent of structural or functional knowledge, would be helped by a larger use of simple diagrams illustrating anatomic and physiologic details, but something must be sacrificed to brevity and possibly the authors bring enough within grasp to satisfy the fundamental necessities of understanding.

The discussion of the various gases and their action is necessarily brief but essentials are at hand and the use of short bibliographies must enable one to get at finer details. It seems rather a pity that in relation to the commoner dangerous gases case reports with details of the setting of the accident are not given. In the experience of the reviewer such reports supplemented by a judicious amount of explanation make the best means of conveying the practical information which field men require.

The monograph is well indexed and can be endorsed as a thoroughly useful addition to the literature on industrial toxicology.—*C. K. Drinker.*